2018-09-10 Basic Models (1.1)

1.1 Basic Models

1. Let us model the altitude of a boulder thrown by a catapult:
(There can be many instances at which we can model the altitude of the boulder but we will consider the case where the boulder just leaves the catapult)

Step 1. Which basic Physics principle should we use?

a. Conservation of Angular Momentum

(The law of conservation of angular momentum states that angular momentum will remain constant when no external torque acts on an object (related to rotation, commonly caused by orbits around a point))

b. Newton's 2nd Law $F = ma$

(Easiest one to use, more general, works even when energy is NOT conserved)

c. Rate of Change

(Equals to rate in - rate out, for example water flowing in and out)

d. Conservation of Linear Momentum

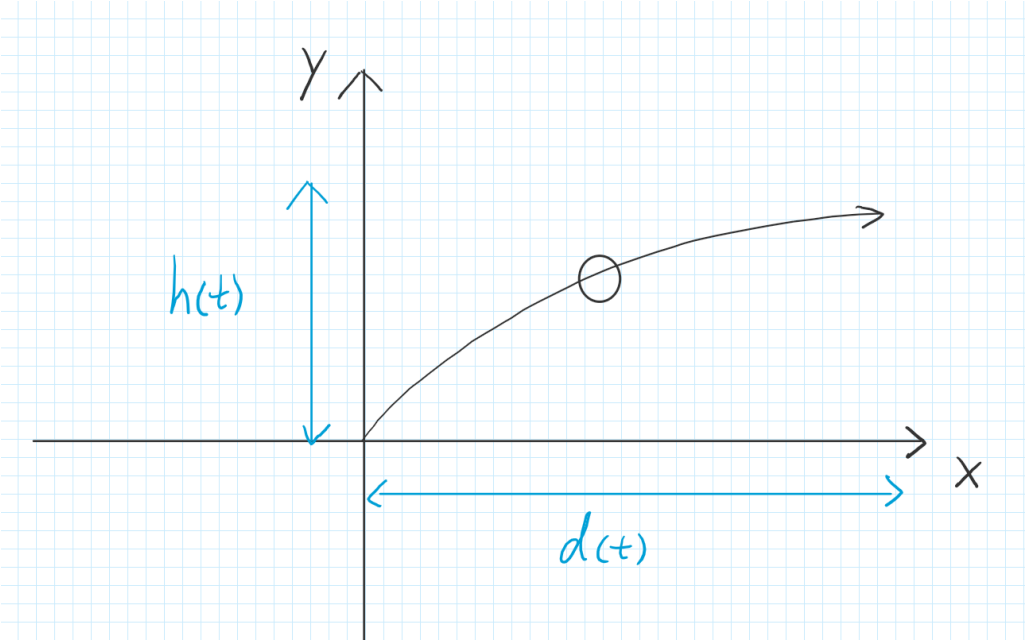
(The law of conservation of linear momentum states that linear momentum will remain constant when no external force acts on an object (commonly used to model two objects of different mass and/or velocity colliding))

e. Conservation of Energy

(The law of conservation of energy states that energy can neither be created nor destroyed; rather, it can only be transformed or transferred from one form to another. In this case, some energy may be lost during the process, for example due to air resistance. However, the energy at any point in the motion of object will remain constant; it simply changes form (kinetic, potential, etc))

Define:

- h(t) = altitude (in meters) of the boulder 't' seconds after it is launched (purely y-component)
- d(t) = displacement (both in x-axis and y-axis, but we can ignore x-axis since the question just asks for the altitude of the boulder which is only in the y-axis)
- v(t) = h'(t) = vertical velocity



Step 2. We need to know:

1. Acceleration = v' (= d'')= (h')' = h''

- no acceleration on x-axis, gravity and air friction on y-axis
- Since we are modelling the altitude, we do not need to keep track of the displacement in the x-axis.

1.5 How does altitude get into acceleration and force?

2. Force = Gravity + Friction

- The two main forces that contribute to the boulder's altitude
- All other forces are instantaneous (very short), therefore they are ignored for the purpose of this analysis e.g the force of the catapult on the boulder.

$$F = -mg \pm \gamma v$$

- Because the boulder will go up, the altitude is positive
- Therefore, since gravitational force "mg" acts downwards, it is negative
- " γ " represents all the factors (constants) that affect the air resistance or the motion of the boulder, other than gravity, such as density. It's value could be either positive or negative depending on if the object is going up or down
- "m" is already known